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THE RELATION OF HANDLING TO DECAY IN CALIFORNIA NAVEL ORANGES; SEASON OF 1910-11.

INTRODUCTION.

During the shipping season of 1910-11 there has been considerably greater loss from blue-mold decay in Washington navel oranges in transit from California to eastern markets than has prevailed for four or five years. Following the work of the Bureau of Plant Industry in investigating the causes of decay in California oranges begun by Mr. G. Harold Powell in 1904 and continued through five successive seasons, there was a very general improvement in the system of handling and marketing citrus fruits in California, and the losses from decay were effectively checked or reduced to a negligible minimum. During the early part of the present season, however, many shipments of navel oranges from California showed heavy decay from blue mold, and the conditions which were responsible for this seemed to be due to a number of factors acting singly or in combination.

The season was an unusual one in many respects. The crop was the largest in the history of the industry; the season was most unfavorable for handling, frequent rains interrupting picking operations and making ideal conditions for the development of blue mold; thus the labor was pushed to the limit in the groves and in the packing houses. Under these conditions it is not surprising that the standard of handling was lowered; moreover, it is more than probable that the fruit was unusually tender and that it was unable to withstand the kind of handling given under ordinary circumstances.

Early in the season a bulletin was issued by Mr. Powell, now secretary and manager of the Citrus Protective League of California, calling attention to some of the measures which should be observed in preventing decay. In February the league requested the Department of Agriculture to delegate a representative of the staff of the Bureau of Plant Industry to make a detailed study of the handling

methods practiced by the growers during the season, with a view to determining the relation between the treatment given the fruit and the occurrence of the decay. The point was made that many of the growers and packing-house managers, while appreciating the importance of careful handling, felt that the trouble was due to causes beyond their control and were inclined to attribute the unusual prevalence of the decay to some new conditions which caused the fruit to be unusually weak. From the beginning it was believed by Mr. Powell and the Bureau of Plant Industry investigators that there was a combination of factors which brought about the decay, but that the main cause was an unconscious lowering of the standard of handling in consequence of the extra large crop of the season. It was considered advisable to make as thorough a study of the conditions in southern California as was possible under the circumstances, and Mr. C. W. Mann, scientific assistant, then located in the State doing work along other lines, was detailed to begin the investigation. Later in the season, after the close of the bureau's campaign in Florida, Mr. A. W. McKay and Mr. Burr B. Pratt were sent to southern California. The field work in connection with this investigation has been carried on by these three men. Mr. Powell and Mr. George W. Hosford, the latter formerly associated with the bureau work but now manager of the San Dimas Lemon Association, have given valuable advice and assistance as collaborators.

The work was planned along lines similar to those followed in the earlier investigations of the bureau—a determination of the percentages of mechanical injuries in various packing houses, a study of the relation of these injuries to the occurrence of blue-mold decay, and the investigation of the effect of various house-handling methods, washing, brushing, and packing without any special cleaning treatment, all furnishing data for a comparison of the behavior of fruit very carefully handled by the bureau investigators with the same fruit handled under ordinary commercial conditions.

OCCURRENCE OF MECHANICAL INJURIES.

A count of mechanically injured fruit in many packing houses showed sufficiently high percentages of injuries to account for the greater part, if not all, of the loss from decay. A very decided increase over recent seasons in the occurrence of mechanically injured fruit was found in most of the packing houses examined; in fact, the increase in percentages of mechanically injured fruit in houses which had been doing good work in previous seasons was surprising and significant, indicating a serious letting down in the standard of handling. The average injury in the different houses examined ranged from 4.8 per cent to as high as 53.6 per cent. The injuries made by individual pickers were as high as 85 per cent. Most of the

injuries consisted of clipper cuts, but there were large numbers of abrasions of various kinds, gravel punctures, scratches, etc.

Loose and projecting nails in the field boxes were found to be a frequent source of injury. In one instance it was found that nearly half of the field boxes in use by a large grower were defective in this respect and were injuring a large proportion of the fruit. These boxes had been in use during the entire season, and although an inspector was employed who was supposed to look after the careful handling of the fruit, he failed to observe the defective boxes.

The condition of the clippers in use was also found to be the cause of considerable injury. On one large place, which prides itself on its careful handling methods and where a system of inspection has been developed, the clippers were found to be in such condition that it was almost impossible to make a close, smooth cut without injuring the fruit. In this instance continuous sharpening of the clippers had worn them down to sharp points which projected in such a way that the slightest touch slit the skin of the orange, resulting in clipper cuts which, although small and apparently insignificant, were ideal places for the development of blue mold. This fact completely escaped the inspector, who had been in the habit of looking only for ordinary defects. This instance shows the necessity for constant vigilance on the part of inspectors, foremen of picking gangs, and managers of packing houses. It is necessary to be always on the lookout for the unusual and the exceptional, as small details are frequently of the greatest importance. These factors have been so often referred to that further repetition might seem unnecessary, but the experiences and observations of the work of the past season show that they can not be too strongly emphasized. They are likely to be overlooked unless all concerned with the handling of the fruit are constantly on the alert.

OCCURRENCE OF NATURAL DEFECTS.

There were unusually high percentages of naturally defective fruits. Early in the season many oranges were affected with black rot and the proportion of "splits" at the navel end of the fruit was unusually large. There is a direct connection between the occurrence of these defective fruits and blue-mold decay after the fruit is packed. Fruits affected with black rot are weakened and the broken-down tissues become easily infected with blue mold. The "splits" may be considered as being in the same category with mechanical injuries. Many of the "splits" are too small to be detected in the grading and many affected oranges are packed into the boxes.

The indications are that wither tip (*Colletotrichum glæosporioides*) was prevalent in some of the districts. It was impracticable to make

systematic determinations or counts of fruits infected with the disease. In some instances the characteristic spots of wither tip developed in the packed fruit and blue mold almost invariably followed.

These disease factors are not mentioned here as explanations of the occurrence of the heavy blue-mold decay during the season of 1910-11; they are cited to indicate that they were not overlooked in outlining the scope of the work.

While a certain proportion of the decay in transit was undoubtedly due to the causes mentioned, which were in a large measure beyond the control of the grower, the picking-gang foreman, and the packing-house manager, the investigations made show that by far the greater proportion of the decay was due to mechanical injuries as a result of poor handling. The data obtained amply demonstrate that even in such unfavorable seasons as the present one oranges can be handled in the grove and the packing house with sufficient care to insure their sound condition on arrival in market. In a season like the one just closing it is doubly important to handle the fruit with unusual care in order to avoid injury to the tender skin. Special precautions are necessary in unusually unfavorable seasons if a high standard and a reputation for soundness are to be maintained.

HANDLING AND PACKING EXPERIMENTS.

Handling and packing experiments designed to make a direct comparison of fruit very carefully handled with the same kind of fruit handled under ordinary commercial conditions were made. In most of these experiments the actual picking, grading, handling, and packing of the fruit were done by the bureau investigators. Some packing of the carefully picked and handled fruit was done by an experienced packer working under the direct supervision of the bureau representatives. A comparison of carefully handled brushed and unbrushed fruit with commercially handled brushed fruit was made, and also a comparison of carefully handled washed fruit with commercially handled washed fruit. The work was carried on in 25 different packing houses, and in all 49 experimental series of fruit were prepared. The data which have been obtained, therefore, cover a wide range of conditions and are sufficiently comprehensive to serve as a safe basis for deduction. In all of the experiments the results were clear cut and consistent throughout and showed a definite relation between the kind of handling given the fruit and the occurrence of decay. The fruit was all packed and held two weeks in the packing houses, and the percentages of decay in the various lots were determined by actual count.

TABLE I.—*Average percentages of decay in carefully handled and in commercially handled Washington navel oranges in 1911.*

Number of experi- ments.	Carefully handled.			Commercially handled.		
		Per cent.		Per cent.		Per cent.
6	Not brushed or washed	3.35	Brushed	7.50	Brushed	16.20
10	Not brushed or washed	2.75	Washed	9.50	Washed	21.55
17	Not brushed or washed	2.00			Not brushed or washed.	10.3

Table I shows a comparison of the averages of decay found in the same fruit under different methods of handling. Dry brushing increased the decay to more than double that found in the untreated lots, and washing increased it to more than four times as much. The washing and brushing given were the ordinary house treatments; no attempt was made to modify these. Under ordinary commercial handling dry-brushed fruit showed more than four and one-half times the decay found in the untreated carefully handled fruit, and washing increased the decay to nearly eight times as much, while the untreated commercially handled oranges showed a decay five times as great as that found in the carefully handled fruit. The effect of the extra house handling is strikingly apparent, indicating the necessity of keeping the handling methods as simple as possible. Brushing should not be done except when necessary, and washing should be resorted to only when it is unavoidable on account of smut. Both the dry brush and the washer are not only possible sources of injury, but both are very effective in distributing the infections and inoculating any broken places in the skin. The washer is much more effective in this respect than the dry brush, and the presence of the water acts as an additional agency in spreading the infection.

The greater decay in the commercially handled uncleared fruit as compared with that carefully handled must be attributed to the kind of handling given the fruit in the grove and the packing house.

TABLE II.—*Average percentages of decay in all brushing and washing experiments with Washington navel oranges, 1911.*

Number of experi- ments.	Carefully handled.			Commercially handled.		
		Per cent.		Per cent.		Per cent.
11	Not brushed or washed	2.70	Brushed	7.20	Brushed	13.60
11	Not brushed or washed	3.50	Washed	9.50	Washed	21.50
	Average	3.10		8.35		17.55

Table II is a summary of all washing and brushing experiments made, including all incomplete series. The averages show the effect of the extra handling when cleaning operations are necessary.

TABLE III.—*Average percentages of decay in all carefully handled and commercially handled experiments with Washington navel oranges, 1911.*

Treatment of fruit, if any.	Carefully handled.	Commercially handled.
	Per cent.	Per cent.
Brushed.....	2.7	13.6
Washed.....	3.5	21.5
Not cleaned.....	2.3	9.6
Average.....	2.8	14.9

Table III is really a summary of all of the investigations made and is a fair and direct comparison of the results of careful handling and commercial handling in the various houses where the work was carried on, the decay in the commercially handled fruit being more than five times greater than that found in the carefully handled lots.

EFFECT OF HIGH PACK.

It was thought that the extra high pack made in a number of houses might be doing considerable injury to the unusually tender fruit. A comparison of high packing with the same fruit packed firm but not extra high showed only a slight increase in the decay found in the high pack. The same kind of fruit was used in all these tests, and both carefully handled and commercially handled lots were included. The figures given in Table IV are the averages obtained from 10 experiments.

TABLE IV.—*Average percentages of decay in Washington navel oranges packed firm and those packed extra high, 1911.*

Carefully picked:	Per cent.
Careful, firm, medium high pack.....	2.00
Commercial high pack.....	3.10
Ordinary commercial pick:	
Regular commercial pack.....	9.23

The high-pack experiments, unfortunately, were not made until after the heavy rainy season was passed and it is possible that more decay would have developed in the extra high packs earlier in the season. It is of course possible to carry the high pack to extremes, and where a high pack is made care should be taken to have the fruit firmly placed throughout the box. Injury from pressure against sharp edges and corners must be avoided.

CONCLUSION.

It is not considered necessary to give detailed and individual records. The industry is concerned only with the summaries of the records, as it is only from these that safe and intelligent deductions may be made. An extended discussion of the results is also unneces-

sary, the earlier work of the Bureau of Plant Industry being familiar to a large majority of the orange growers of southern California, and the packing-house demonstrations which were made in connection with this later study are amply sufficient to show the fact that even under the unfavorable conditions which prevailed during the season fruit may be handled with sufficient care to insure its sound condition on arrival in market.

The solution of the decay problem as demonstrated by the earlier bureau work was shown to depend upon business methods and organization of the industry. The work of the present season corroborates the results of the earlier work in every respect and indicates that the proper solution of the difficulty rests mainly with the packing-house management.

It may be asserted by some that the standard of work carried on by the bureau field men is impracticable under commercial conditions. This is not true. The nearer the ideal methods of care and management can be approached the more certain will be the results. The industry should always be prepared for the exceptional and the unusual.

For a detailed report of former investigations into the causes of the decay of California navel oranges, the reader is referred to Bulletin 123 of the Bureau of Plant Industry, entitled "The Decay of Oranges while in Transit from California." A report upon similar investigations in Florida was published as Circular 19 of the Bureau of Plant Industry, entitled "The Decay of Florida Oranges while in Transit and on the Market."

A. V. STUBENRAUCH,
*Expert Acting in Charge of
Field Investigations in Pomology.*

Approved:

B. T. GALLOWAY, *Chief of Bureau.*

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